



MECHANICAL DEVELOPMENT FACILITY

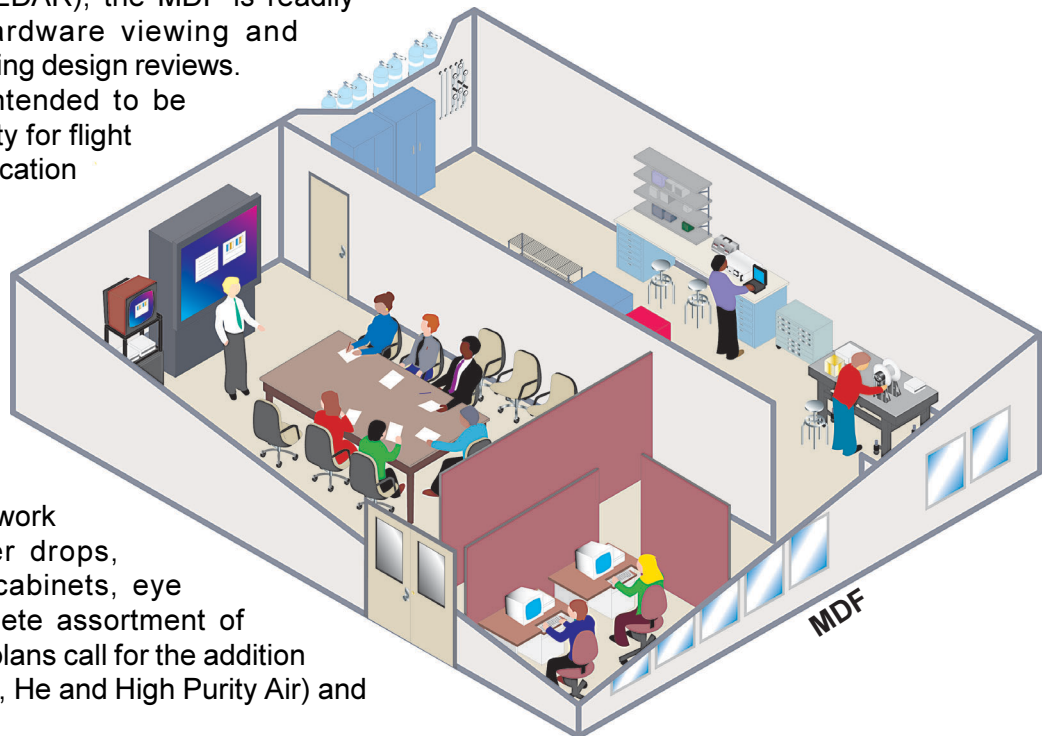
Purpose:

To provide a safe, controlled environment for the assembly and evaluation of developmental engineering hardware.

The Mechanical Development Facility (MDF) is a keycard access controlled area of approximately 550 sq ft, located in Building 4666. To further enhance support provided to the various product lines and Directorates, personnel of the Structures, Mechanics, and Thermal Department utilize the facility for breadboard build-ups, mechanical system checkouts / evaluations and work with hardware mock-ups. Located adjacent to the Collaborative Engineering Design and Analysis Room (CEDAR), the MDF is readily accessible for hardware viewing and demonstrations during design reviews.

The MDF is not intended to be used as a test facility for flight hardware or a fabrication shop.

At the present time, available equipment includes: an optical grade work bench, two Electro-Static Dissipative (ESD) work stations, computer drops, lockable storage cabinets, eye wash and a complete assortment of hand tools. Future plans call for the addition of a gas panel (GN₂, He and High Purity Air) and sink / wet area.



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COLLABORATIVE ENGINEERING DESIGN AND ANALYSIS ROOM

Purpose:

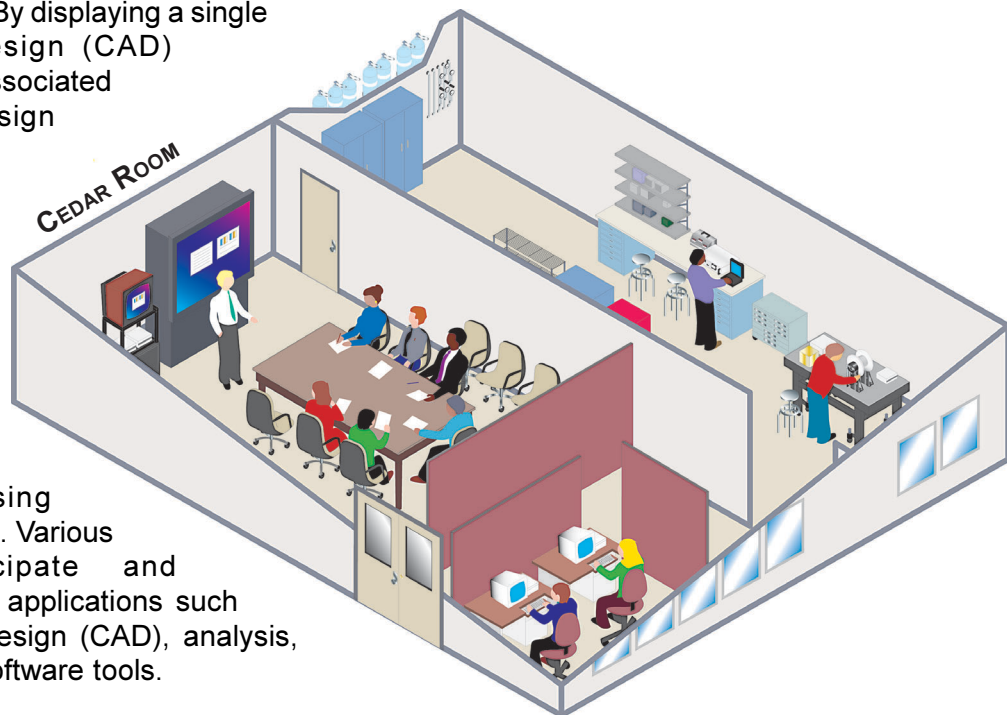
To operate as an integrated structural, thermal, aerodynamic, and system control design center geared to support the implementation phase for vehicle and payload specification, performance modeling & simulation, design, and analysis.

Collaborative Engineering Design and Analysis Room (CEDAR) is an engineering design conference room where people from various locations can meet and review detailed design and analysis information. There is a large screen projection system that is run from high-end computer systems with various design and analysis software installed. Projects that are required to share design and configuration management information are able to hold real-time design reviews. By displaying a single computer aided design (CAD) master model and associated analysis results, design teams can meet and address specific and detailed technical issues.

Engineers can also virtually meet with their colleagues across NASA centers and with industry using collaboration software. Various sites can participate and simultaneously share applications such as computer aided design (CAD), analysis, and common office software tools.

Projects that benefit greatly by the real time display of detailed design and analysis data are NASA-wide as well as In-house.

CEDAR is located in Building 4666 and can seat approximately 20 people. CEDAR can be scheduled on-line at:
<http://www.ies.msfc.nasa.gov/ed23/cedar>.



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Environmental Test Facility

Purpose:

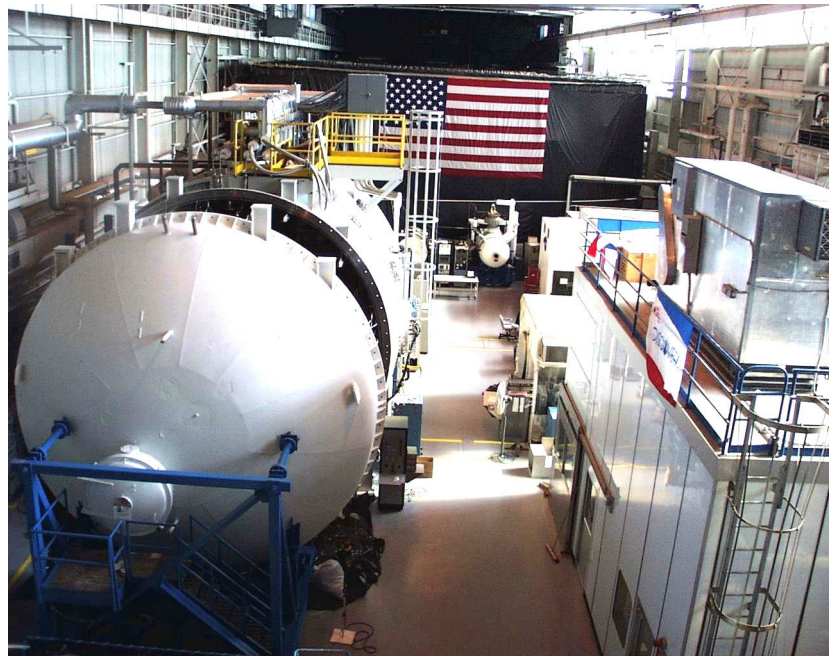
To provide a wide range of simulated environments for development, qualification, and acceptance testing of space flight hardware.

The Environmental Test Facility (ETF) in Building 4619 provides the capability for thermal vacuum bake-out, optical cleanliness bake-out, thermal humidity and thermal altitude testing. Possible simulated environments range from ambient pressure to 5×10^{-8} torr with temperatures from 185°C to 200°C. Within these ranges, it is possible to simulate conditions related to ascent, descent, and on-orbit environments as well as conditions related to shipping and ground storage environments.

The facility consists of sixteen thermal vacuum chambers, nine thermal humidity chambers, one thermal altitude chamber and two Class 10K clean rooms. Chambers range in size from a 2 ft bell jar to a 20 ft diameter x 28 ft long thermal vacuum chamber that can accommodate a 15-ton flight article. The chambers are operated 24 hours a day, 250+ days a year, by a team of engineers and technicians that have more than 150 years combined vacuum testing experience. The large number of chambers housed in close proximity, along with the expertise and experience of the ETF team, allows for support of multiple tests during each shift which results in very reasonable pricing for ETF customer.

Environmental simulation is necessary to verify flight article design, manufacturing processes, and workmanship through functional testing at extreme conditions. In addition, thermal cycling can be used to simulate aging, and thermal balance tests can be used to correlate thermal modeling predictions.

The ETF supports all flight programs. Some of the programs recently supported include the International Space Station, Chandra X-ray Observatory, Propulsive Small Expendable Deployer System and various Microgravity research experiments. All of the Ku-band antennas utilized by the shuttle fleet also are qualified and re-qualified for flight in the ETF. The ETF Team stands



ready to provide environmental simulation testing support to insure the safe, reliable operation of all space flight hardware.

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Thermal Development Facility

Purpose:

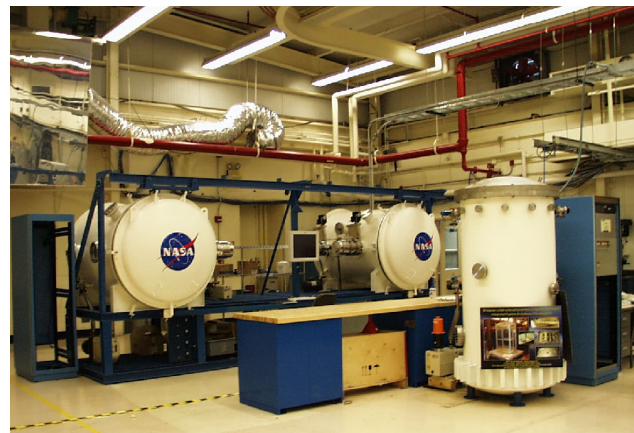
To develop and implement aerospace thermal applications, technologies, and test methods.

The Thermal Development Facility (TDF) is a joint initiative that is managed by the two thermal groups at MSFC, the Thermodynamics and Heat Transfer Group and the Thermal and Fluids Systems Group. The TDF facilitates the development and implementation of aerospace thermal applications, technologies and test methods. The TDF also provides a unique “hands-on” environment enabling thermal technologists to stay abreast of the latest thermal control/protection and test approaches including alternate techniques not employed in MSFC programs. Facilitation of basic IR&D is a critical part of maintaining engineering excellence within the Engineering Directorate at MSFC. As a joint initiative across the thermal discipline at MSFC, the TDF supports all MSFC productlines.

The TDF is located Building 4612 and includes approximately 5000 ft² of high-bay space and over 1000 ft² of general-purpose shop/laboratory/storage space. Dedicated facility capabilities include:

- Two 4-ft diameter by 6 ft long vacuum chambers
- One 2 ft diameter by 3-ft long bell jar
- Flow boiling facility capable of subzero conditions when operating up to a 5 KW load
- One 30”x31”x36” Temperature/Humidity Chamber capable of -40C to 200C
- Various cooling carts with cryogenic capability and miscellaneous coldplates, heat exchangers, etc.
- Wide range of instrumentation
- Highly developed data acquisition and control

As part of the Thermal and Fluids Group, the TDF operates in partnership with MSFC’s Environmental Test Facility (ETF). This provides direct access to the significant resources



possessed by the ETF. This includes not only the wide range of environmental testing systems and equipment but equally important is the wide range of expertise, skills and crafts. The combination of the two thermal groups provide access to approximately 78 engineers and 16 technicians with a diverse range of knowledge encompassing all aspects of thermal design, analysis and verification in support of MSFC’s mission.

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Structural Test High Bay Facility

Purpose:

To provides laboratory space, test cells, and utility support for structural and dynamic test activities.

Three high bay structures comprise this facility: the Central High Bay, the East High Bay, and the West High Bay. Utilities provided include gaseous nitrogen up to 5,000 pounds per square inch gauge (psig), missile grade air up to 3,500 psig, shop air up to 100 psig, and electric power up to 480 VAC (3 phase). The Central High Bay is a 169 x 161 x 155 ft load reaction facility with an access door 60 x 75 ft and a massive 55 x 55 ft concrete test floor below a moveable load reaction crosshead, adjustable in height (5 1/2-in increments) from 40 to 115 ft. The concrete floor varies in thickness from 5 1/2 to 26 ft and is equipped with 2,356 ASTM A-354 steel and 2 3/4-in tie downs on 18-in centers. The tie-downs are rated at 110,000 lbf in tension or compression and 20,000 lbf in shear loading. Massive walk platforms spanning the two north towers at intervals of 20 ft are designed to react shear loads. Loads of 30,000,000 pounds force (lbf) vertically and 2,400,000 lbf laterally can be reacted in the facility. Two overhead bridge cranes, each with dual independent trolley hooks rated at 15,000 lb, are available for test article handling. The East High Bay is a 95 x 203 x 97 ft high bay area with an access door 40 x 40 ft and a massive concrete test floor 70 x 160 x 10 ft thick. Reaction load plates, 400,000 lbf tension and 45,000 lbf shear per plate, are symmetrically affixed on 10 ft centers to the test floor. Two overhead bridge cranes, each with dual independent trolley hooks rated at 20,000 lbs and 5,000 lbs and a maximum hook height of 80 ft, are available for test article

handling. The West High Bay provides laboratory space for dynamic test operations and other functions remote to structural and dynamic test activities. Vibration and transient shock test cells are located adjacent to the high bay. Structural testing is performed at ambient and non-ambient environmental conditions including elevated and cryogenic temperatures.



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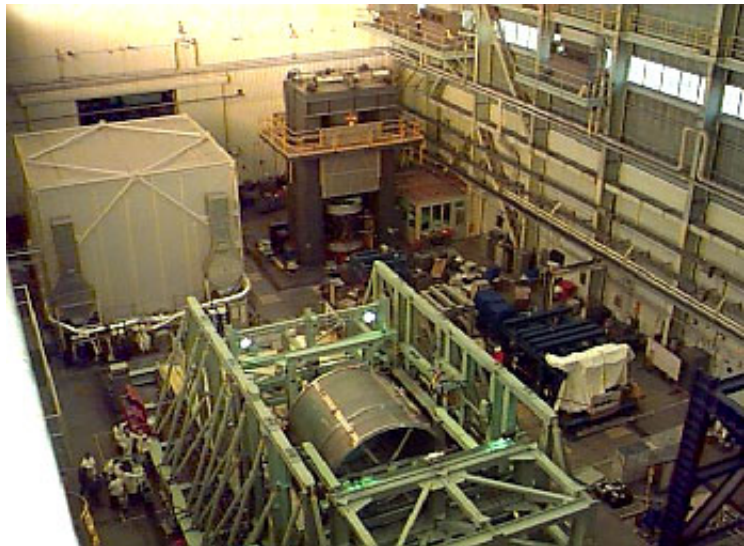


Large Structural Quasi-Static Load Facility

Purpose:

To provide for full-scale quasi-static structural load testing and functional performance verification.

The loading profiles are applied using automatic servo loop load control systems in this facility. The capability for quasi-static and fatigue testing modes are available in the range of 112 active channels. The loading profiles, application rates, and release of loads are computer controlled and the load limit and error tolerance controls are utilized for test article protection. An extensive inventory of force transducers and hydraulic actuators are available ranging from a few pounds-force to several million pounds-force. The Structural Loads Test Measurement Acquisition System (SLTMAS) is the main data acquisition system used to measure the structural strength test responses. The SLTMAS consists of 4,600 channels with an overall system accuracy of $\pm 0.075\%$ of full-scale range up to a 100kHz sample rate. The binary data acquired is converted to engineering units in a background process and stored to a hard disk that then is immediately available to the analyst. On-line access to data is provided to stress analysts in engineering units. Data formats include Excel spreadsheets with two-dimensional graphic display of discrete values and plots, and three dimensional finite element values. Elastic strain data is processed in real time with corrections for temperature affects. Supplementary strain gauge data can be acquired on surfaces that include high radius of curvatures using photo elastic strain measurement technology. Photo elastic strain measurements are acquired with a modular reflection polariscope system that includes a null balance compensator, telemicroscope, monochromator, stroboscopic light source, and a 35mm camera.



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COMPONENT/SYSTEM QUASI-STATIC LOAD FACILITY

Purpose:

To perform structural strength test capability for small structural elements and components.

Several universal load reaction structures exist for testing struts, brackets, plates, panels, etc. A large Gilmore Universal Test Machine is capable of applying 2,000,000 pounds force (lbf), in tension or compression to failure (shock) load and 3,000,000 lbf. in tension or compression without failure (no shock). The Gilmore machine can accommodate test articles in size up to 10 x 10 x 25 ft. The machine is hydraulic servo controlled, has a stroke of 3 ft, speed ranges up to 3-in/min, and multiple full scale load ranges. Three universal structural test machines include a 50,000 lbf. capability with 21 inches between columns and a 35-in tension/33-in compression height; a 120,000 lbf machine with 30 inches between columns and 95-in tension or compression height; and a 500,000 lbf machine with 30 inches between columns and 108 inches plus 12-inch stroke in tension, 108 inches plus 12-inch stroke in compression. Speed ranges from 0.001 to 20-in/min are available on the latter two machines.



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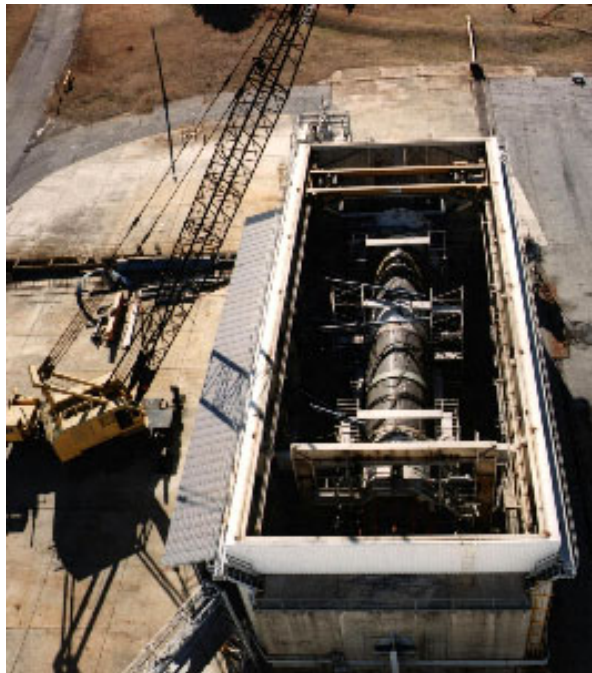


HAZARDOUS STRUCTURAL TEST FACILITY

Purpose:

To provide structural strength and pressurization test capabilities in an area controlled for hazardous test operations.

The mechanical load control and data acquisition and processing systems described for the “Large Structure Quasi-Static Load Facility” are common to this facility and provide identical features and performance characteristics. The test bay, measuring 40 x 94 x 48 ft, has a 5-ft thick reinforced concrete floor with 12-ft thick end walls capable of reacting loads of 2,500,000 lbsf. The roof is removable for easy access to install and remove large structural test articles. A hydro accumulator pressurization system allows rapid automatic pressurization of structures within the building. The floor is below grade and designed for containment of pressurization fluid in the event of test article rupture. This system includes a 3,000-gallon water tank as well as 500 and 3,000-gallon air tanks which are connected to 3,500 pounds per square inch gauge (psig) missile grade air through a pressure reduction station. An overhead bridge crane has dual independence trolleys with hooks rated at 5,000 lb available for test article handling.



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CRYOGENIC STRUCTURAL TEST FACILITY

Purpose:

To provide cryogenic simulation, structural strength, and pressurization test capabilities in an area controlled for hazardous test operations.

Cryogenics include LN_2 , LH_4 , and LH_2 stored in volume for large test articles. The mechanical load control and data acquisition and processing systems described for the “Large Structure Quasi-Static Load Facility” are common to this facility and provide identical features and performance characteristics. Test article dimensions up to 33 ft diameter and 60 ft length are accommodated. Load reaction structure compatible with load application systems is in place for tensile, compression, moment, and shear loads. Unique support structure and interface hardware are customized to test article requirements.



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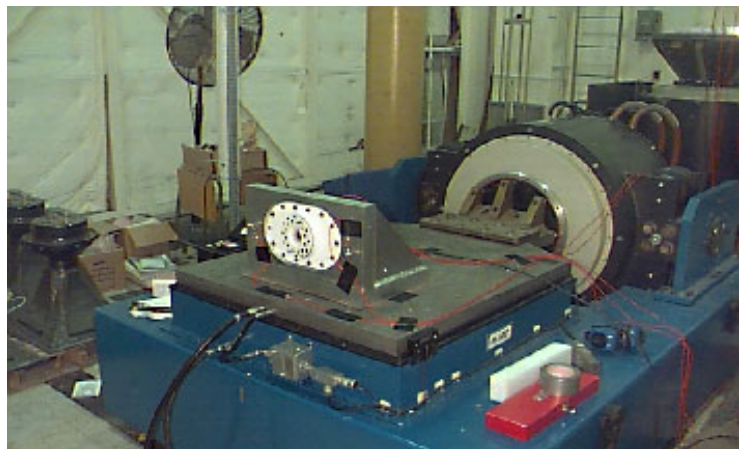
VIBRATION TEST FACILITY

Purpose:

To provide experimentally derived dynamic loads that simulate the launch and on-orbit environments to which flight hardware is exposed.

The Vibration Test Facility is comprised of two separate test cells located adjacent to high bay structures. A total of eight electrodynamic exciters and five amplifiers are dedicated to development and certification vibration testing of flight and ground support hardware. Dynamic excitation controlled up to 40,000 force-pounds is available through the use of five digital vibration control systems. Two of the control systems provide sine sweep, broadband random, sine on random, random on random classical shock and shock response spectrum (SRS) control functions.

Other control features include 80 dB dynamic range, real time 32 channel control, tolerance limited spectra, test article response limitation,



and real time signal analysis. Shaker head expanders allow mounting surfaces up to 5 x 5 ft. Acceleration data can be acquired in real time up to 32 channels in both time and frequency domains and formatted to conventional and specified test article requirements. An additional 48 channel recording capability can be utilized for post processing of dynamic response data. Customized vibration fixture design and manufacture can be provided through in-house organizational resources.

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VIBRO-ACOUSTIC TEST FACILITY

Purpose:

To provide experimentally derived vibro-acoustic loads that simulate the launch and on-orbit environments to which flight hardware is exposed.

The Vibro-Acoustic Test Facility consists of a reverberation chamber, a progressive wave tube, and an anechoic chamber. Vibro-acoustic development and certification testing is performed in a 5,000 cubic ft concrete chamber with the capability of up to 200,000 acoustic watts input, 172 dB Overall (OA) Sound Pressure Level (SPL) in a progressive wave tube and 164 dB OA SPL in a diffuse field. Test articles up to 500 cubic ft can be placed in the diffuse field. Electromagnetic drivers are available for noise levels up to 139 dB OA SPL. An adjacent 3,000 cubic ft anechoic chamber provides the capability for transmissibility and absorption studies, as well as acoustic emission measurements, to exceed NC-40 requirements. Up to eight microphones can be multiplexed for acoustic level control and 32 channels of acceleration response can be analyzed on-line. Control tolerances are ± 2 dB per 1/3 octave and ± 2 dB overall.



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PYROTECHNIC SHOCK TEST FACILITY

Purpose:

To provide experimentally derived shock loads that simulate the launch environments to which flight hardware is exposed.

The Pyrotechnic Shock Test Facility is a hazardous area equipped for generating dynamic transients with explosive materials. Mild detonating fuses, linear shaped charges, and

Twelve channels of transient pyrotechnic response data can be acquired and post-processed in the time domain or SRS for one pyrotechnic event.



blasting caps are used to generate flight input transient shock simulation to test hardware commonly mounted on a suspended steel plate. Shock levels up to 30,000 Gs shock response systems (SRS) and 10,000 Hz can be generated. Pyrotechnic devices used in aerospace flight applications can be evaluated and characterized as to the SRS response resulting from detonation.

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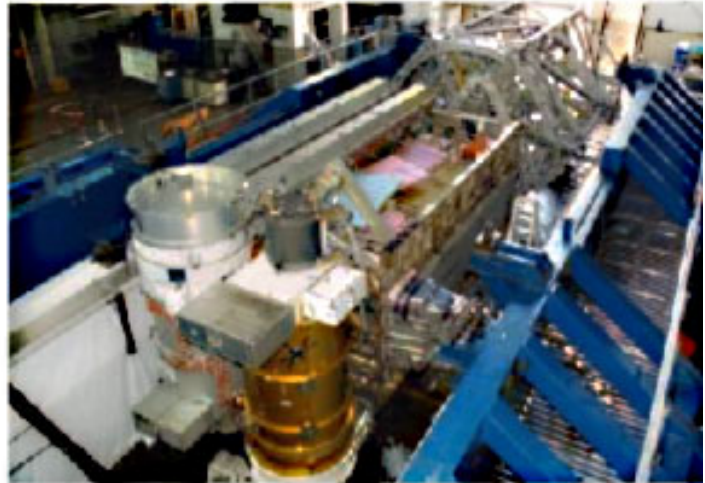
MODAL TEST FACILITY

Purpose:

To dynamically characterize structural systems identifying their modes of vibration including frequencies, damping values, and shapes.

The Modal Test Facility is equipped for testing flight structures, systems, payloads, and components requiring fixed, fixed-free or free-free boundary conditions. Customized fixture design and manufacture can be provided through in-house design organizational resources. Flight hardware requiring a 100K cleanliness environment can be tested in a 30 x 30 x 30 ft 100K clean room. Test article excitation using transient, sinusoidal, or random input is accomplished by a numerous variety of impulse hammers and electrodynamic exciters. A maximum of six input forcing functions with peak force levels up to 1,000 pounds can be simultaneously applied. An inventory of 1,200 accelerometers (0.5-500 Hz) is available for instrumentation of the test article. Simultaneous acquisition and time averaging of 224 input channels of force input and acceleration response output can be digitally processed and stored as frequency response functions in real time at a frequency up to 10 kilohertz. State-of-the-art modal analysis software, residing on computer workstations, utilizes basic and complex time and frequency domain algorithms to calculate modal parameters of frequency, mode shape, and damping. Animated mode shape display, extensive hard copy modal data formats, and various tests to analytical data correlation and comparison methods are available. Advanced modal parameter acquisition techniques such as

“Time Average Holographic Interferometry” are used to reveal contours of amplitude on the surface of a vibrating object. The primary advantage of this approach when compared to more conventional techniques is that displacement information can be obtained over



an entire surface of interest producing complex high frequency mode shape information readily from a single holographic image. Modal holograms can be acquired throughout a 0-35kHz frequency range with a displacement sensitivity of approximately 125 nm using piezoelectric shaker excitation.

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